MADRAS
AGRICULTURAL DEPARTMENT

YEAR BOOK

1923

MADRAS
PRINTED BY THE SUPERINTENDENT, GOVERNMENT PRESS

1924

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YEAR BOOK, 1923.

SHORT LESSONS TO A CULTIVATOR FROM THE KASARAGOD COCONUT STATION.

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A ryot who saw the Kasaragod Coconut Station before it was acquired by the Department wonders at its present condition whenever he visits it now. He does not often believe the statement that the present improved condition is brought about by intercultivation of the plots. He never realizes that intercultivation is such an important thing in the successful cultivation of a coconut garden. He knows by experience that good crops can be had by adequate manuring and watering, but it never strikes him that intercultivation is such an important thing.

When such a ryot is taken round the Farm and shown the block number III which has been kept uncultivated ever since the Farm was acquired, it reminds him of the old condition of the Farm. He looks with keen eyes at the neighbouring blocks of II and IV which are being intercultured. He walks up and down the cultivated and uncultivated blocks and looks at the crowns of the trees. He at last signifies his appreciation of interculture by patting the trunks of the trees in the intercultivated blocks with a smiling face.

The importance of interculture is seen by the yields of the three abovenamed blocks for the last four years.

Blocks number.	Treatment.	Average yield per tree in 1918.	Average yield per tree in 1919.	Average yield in 1920.	Average yield in 1921.
II	Cultivated ...	18	35	37	45
III	Uncultivated.	18	16	11	15
IV	Cultivated ...	23	30	51	54

From the above table it is evident that the trees in the cultivated blocks have been giving a steady increased yield and at the end of four years the yield per tree has more than doubled, whereas the yield per tree in the uncultivated block has steadily decreased.

The process of interculture is neither difficult nor costly. It consists in ploughing the whole garden twice a year, once in June at the commencement of the south-west monsoon rains and again in November towards the close of the north-east monsoon rains. In addition to these two main ploughings, three or four hoeings are given with a bullock hoe, such as guntaka, in the course of the year at an interval of two or three months. The first ploughing at the commencement of the monsoon facilitates the soakage of rain water into the deeper layers of soil and the second ploughing and the subsequent hoeings help the conservation of moisture. The main object of interculture is to prevent the loss of moisture and plant-food from the soil by evaporation and robbing by weeds. No doubt interculture does not add to the soil moisture or plant-food as is usually done by irrigation or manuring, but it makes

moisture and plant-food available to trees which otherwise would have been lost by evaporation and robbing by innumerable weeds. The loss of plant-food and moisture caused by weeds is generally imperceptible and so does not appeal to ryots. The poor condition of the trees in the uncultivated block III is due to weeds. When a trench is dug in this block and the layers of soil examined, the surface soil is found to be entirely covered with a net work of roots of weeds. The coconut roots just lying underneath this net work as if struggling for plant-food and air. In this block coconut roots do not seem to be vigorous and far spreading, but weak and concentrated close to the trunks of the trees. The local method of watering and manuring close to the trunks of the trees restricts the spread of the root system. Roots come to the surface and tend to concentrate round the trees. In the cultivated blocks, weeds are destroyed and moisture is conserved, and roots do not come to the surface but traverse far and wide and take in plant-food from a larger area. These roots do not suffer much during the hot weather and trees look better and bear more nuts. After every hoeing the corners of blocks and the space round the trees will have to be hoed with a spade or a mamuti wherever the blade of the guntaka has not worked the soil. All these interculturing operations do not cost more than six rupees per acre, that is, little over an anna per tree taking about 60 trees in an acre.

Selection of trees for seed-nuts.—When any one looks into the Yield Register of trees maintained in the Station, he will be struck with the diversity of characters of these trees, some are good and

regular bearers and others are poor and irregular bearers. Crowns of trees indicate variation in the number of leaves, number of spathes and number of nuts in each spathe.

A good tree will have between 30 and 40 leaves in its crown and puts forth 15 or 16 leaves in a year. Usually coconut trees produce a leaf per month, but this varies with different trees. Good trees produce more than 12 leaves in a year whereas poor bearers produce less. There is variation not only in the number of leaves, but also in their position and method of attachment to the trunk. The leafstalk should be short and attached to the trunk in an horizontal position. Trees having drooping leaves with long leafstalks are not good. A long leafstalk denotes a long inflorescence stalk which is objectionable in that it is liable to slip off the supporting leaf base and buckle with the weight of a full bunch of nuts. Further a long leafstalk denotes a flat thin leaf base which may not be strong enough to support the weight of the bunch of nuts. Leaves having long leafstalks will have less number of leaflets and so reduce the leaf surface of the tree. Sun light is very important for plant growth and the horizontal position of the leaves is best suited for the absorption of light.

Generally each leaf puts forth a spathe but irregular bearing trees do not follow this rule and they put forth a lesser number of spathes than leaves In bad trees all the female flowers do not get fertilized and develop but most of them drop off. In a good regular bearing tree a large number of female flowers develop into nuts. Such being the case, the selection of trees for seed-nuts is very

important and much attention should be paid to it. The coconut being a long-standing crop, a mistake once committed in the selection of seed-nuts from poor and irregular bearing trees will be a perpetual mistake which cannot be rectified afterwards unless the trees are cut. Some ryots in a hurry to start new plantations purchase seedlings from all quarters without knowing the parentage of the seedlings which they purchase and others select big-sized nuts from seed-stores which might not be from good bearing trees. Usually nuts on poorly filled bunches are bigger than those on the well filled bunches. All such mistakes can be avoided by selecting trees of middle age which bear regularly and have well filled bunches with fair-sized nuts of thin husk.

The following table shows that nuts harvested from the same trees at different periods of the year differ in their size and oil contents :—

	Lb. of copra from 100 nuts.	Percentage of oil obtained (with country mill).
May-June harvest ...	... 41·3	57·3
July harvest	... 35·5	56·6
September-October harvest	... 35·5	56·6
December-January harvest	... 33·3	57·4
February-March harvest	... 37·3	54·2

It is seen that nuts harvested in May-June are bigger in size and contain more oil, so they are better suited for seed purposes.

Nursery.—After selecting the seed-nuts, the next important thing is to plant them in suitable beds. The land selected for seed-beds should be sandy and freely drained, slightly shaded so as to keep the ground cool, and immune from white ant attack. After plucking the seed-nuts from the

selected trees, they should be kept in a shady place for a month or six weeks before they are planted in the nursery. The usual practice is to plant these nuts vertically in a slightly raised seed-bed at the commencement of the rains, but this method seems to have one or two disadvantages. The young shoot has to force its way up through the whorl of scale leaves which adheres to the base of the ripe nut and in doing so, is much more likely to be infected by fungus and scale diseases than if it forced its way through the smooth surface of the side of the nut. Secondly as a large surface of the nut comes in contact with the soil a greater number of roots start out and penetrate into the soil. These roots get damaged at the time of lifting of the seedlings for planting. Any development of the root system in the nursery must be a considerable drain on the reserve food supply in the nut and if these are damaged before planting it will tell upon the vigour of the tree. In order to minimise the development of the root system in the nursery, the contact surface of the nut with the soil should be lessened and that is done by placing the nuts sideways instead of vertical in the nursery.

Germination commences in about three months and practically all the nuts will germinate within six months of planting. In the hot weather the surface soil should be protected by some grass mulch and the nursery should be regularly watered.

Planting.—The excellent condition of the new plantations at Nileshwar and Pilicode depends upon proper spacing, method of planting and after-cultivation. The coconut is a light demanding tree and cannot thrive under the shade of

other trees. It must have plenty of room so that all its leaves are in the full sunlight. In the neighbourhood of the Farm, where gardens are planted thickly, very few trees grow straight, but they bend in all directions towards the light. In these gardens, trees which have their heads well above their neighbours are bearing better. Trees on the margins of gardens get better light and so yield more nuts.

The space between two trees should, therefore, be at least twice the length of the leaf, that is, they should be about 30 feet apart. If seedlings are planted diagonally 56 seedlings can be planted in an acre giving the same spacing instead of 48 in the ordinary method of planting.

In planting a garden, the main object is to get the plants established as early as possible. The main sources of danger to a newly-planted garden are the hot weather and the attack of white-ants. All possible efforts should be made to give ideal surroundings to the young plants to establish themselves as quick as possible.

The local practice is to plant the seedlings at the bottom of the pits 3 or 4 feet deep on hard soil. The seedlings suffer for want of air, light and soft bed of soil and take a fairly long time to come out of these holes. Instead of this it is better to plant the seedlings on the surface of pits which have been filled up with loose soil. These pits should be 3 feet cube ($3' \times 3' \times 3'$) and dug at least a year before planting so as to allow the excavated soil to be exposed to weather. Some 3 months before planting, these pits should be filled up again keeping a little of the surface soil to one side to fill in round the seedling when planting.

At the time of planting 1 or 2 lb. of fish guano with double the quantity of ashes should be added to the surface soil. One year old seedlings should be planted at the surface of the pit about the end of May or early in June so as to have the full benefit of the succeeding monsoon rains. When planting, three things are to be borne in mind (1) that there should be free drainage and no stagnation of water at the bottom of the seedlings, (2) soil round the seedling should not be allowed to become hard and hot during the hot season, (3) the growing point of the young tree should not be covered with soil. From these one can deduce that the heavier the soil the nearer to the surface of the land the seedlings must be planted. Sometimes it is even necessary to plant on slightly raised mounds in heavy soils. No irrigation was attempted in any of the Coconut Stations and conservation of moisture was effected by interculture alone which has been dealt with at the commencement of this note.

Manuring.—The local method of application of manure close to the trunk of trees is not good. There are not many feeding roots close to the trunk, and so the manure will not be wholly utilized by the tree. A good portion of the manure will be utilized by the feeding roots of the neighbouring trees and also by weeds. The feeding roots of coconut trees are away from the trunk, but by the application of manure close to the trunk, such roots are forced to concentrate round the trunk which is not good for the healthy development of the tree. In level gardens it is advantageous to apply the manure to the whole plot instead of round about the trunks. Fish

manure and ashes form a very good manure to coconut trees. A mixture of 10 lb. of fish manure (if guano 5 lb.) and 20 lb. of ashes per tree should be applied at the commencement of the rains in June. It is better to apply the mixture into the plough furrow and cover it by the next furrow during the commencement of the rains.

Those who are interested in coconut cultivation will do well to pay a visit to the Government Coconut Stations in the Kasaragod taluk of the South Kanara district.

METHOD OF TAPPING COCONUT TREES IN THE WEST COAST.

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The increase in the price of sugar of late has aroused an interest in improving and using coconut jaggery and as such it is important that some facts about the methods of tapping should be recorded, as little has as yet been attempted in this direction. That the coconut tree can serve as a sugar producer is evident from the fact that this industry has been in vogue from time immemorial in places where coconuts are largely grown. But the tapping operations are quite primitive and the manufacturing methods crude and, as a consequence, a product of low quality is obtained which is generally excluded from all high class homes. So long as this operation is in the hands of illiterate conservative people who are ignorant of the most elementary principles of cleanliness and so long as in this country jaggery is consumed by the contented uncivilized poor people a bright

future for this line of production cannot be hoped for. But lately, even well-to-do people have begun to utilize coconut jaggery for household necessities. For the development of a refined method with the application of science a local demand has to be created first. The time has now come to learn and appreciate the possibilities of improvement in several directions and the economic advantages of producing good jaggery for local consumption. If this industry is well developed and the use of coconut jaggery extended the prohibitive price of sugar may not be felt at all by the West Coast people.

The object of tapping may be put as two fold. Young trees during their initial stages of bearing few nuts if tapped for about 6 months or a year and then left alone have been found to produce more nuts and the general activity of the tree is considerably increased. The second object is mainly to obtain juice, whether sweet or fermented. Thus depending mainly on the purpose for which tapping is done young trees or middle aged trees are selected for tapping. Further, when young trees alone are selected the tappers will be able to handle more trees. No special variety best suited for tapping operation has as yet been observed.

Healthy and vigorous trees of any age that have come into bearing are generally selected for tapping. As frequent climbing has to be resorted to, very young trees are not generally selected. The following characters are taken into consideration in selection :—(1) *Vigour of the tree.*—This includes the general condition of the tree, i.e., the thickness of the trunk, the nature of the crown,

the number of leaves and the age of the trees. The thickness of the trunk is not always a sure indication of the high yield of juice, as several trees with thin trunks have been found to yield fairly high. The crown should be pretty strong with closely packed leaves having short petioles. The more the number of leaves on a tree the more adapted it is for tapping. As the yield of juice from old trees is very low they are not selected. In many cases trees are successfully tapped until the time of their maximum bearing. (2) *Nature of the leaf.*—Trees with leaves of a drooping nature are not generally selected since the tappers cannot conveniently sit on the leaves and do the various operations. Further a tree with drooping leaves when tapped will present a forlorn appearance. The close and compact arrangement of the leaves on the crown is considered to be more advantageous. (3) *Spadix.*—Regularity in the production of spadix is an important consideration when selecting trees for tapping. If a tree is not putting forth spadices very regularly, say once in a month, then the efforts of the tapper to tap such trees will be a failure. Two kinds of spadices are recognized by the tappers. Some spadices are long and slender while others are short and thick. These are locally named "Valli Kolai" and "Moodan Kolai" respectively. The former kind being long can be tapped for a longer period. But the disadvantage of the latter in this respect is compensated for, by the thickness of the spadix and the resulting high yield of the juice. The tappers say that spadices with more "Kurumbus" or "Valichingay," i.e., female flowers give better yield of juice. The idea is to select the trees with spadices containing the largest number of flower

stalks since the flow of the juice is from the flower stalks. (4) *Draïnage of the soil.*—This is an important consideration in tapping. Trees in well-drained soils give a better quality and quantity of juice than in ill-drained soils. During the rainy season the trees growing near back waters or in low-lying lands yield less juice and in the hot season they yield more. Trees growing in the interior in laterite soils are generally tapped only in the rainy season.

SEASON FOR TAPPING.

On the West Coast there are two well-marked seasons for tapping. The one commencing from October-November and lasting till April, i.e., the hot weather tapping. The other one is from May to October, i.e., the cold weather tapping. Generally the same trees are not continuously tapped in a year for more than one season except in rare cases. The general custom is to tap for 6 months and then stop. But if the vigour of the tree permits it to withstand this drain, there is no harm in tapping continuously. There are instances of good trees being tapped continuously for more than two years without impairing their vigour and the general condition. Sometimes the time comes when the production of the spadix will be totally stopped all on a sudden for two or three months together or even more. In such cases the tappers will have to wait for the new spadices.

THE AGE OF SPADIX TO BEGIN THE OPERATION.

This is a very important and difficult problem that can be solved only by tapping individual trees. Still the following suggestions will serve as guide. When the first spadix is about to burst

open the succeeding one will be ready to begin the operation in the case of regularly bearing trees. At this stage a slight protuberance at the base of the spadix, due to the development of the female flower can be observed. This is locally known as the "Manikambu." Again at this stage when the top of the spadix is cut and the female flowers taken in hand and squeezed they can be crushed easily and will be soft to the touch. This stage is what is known as the "Milky stage." From this stage, the difference of a week will show another stage called the "Beatened rice stage." It is nothing else than this. The male flowers when crushed similarly will be a little hard to the touch. Of these two stages, which will suit a particular tree, can be judged only by tapping the first spadix and watching the yield and the preparatory manual labour required during the operation. When the lot of the tree sometimes falls in the hands of an inexperienced tapper two or three spadices will have to be tapped consecutively before a sound judgment can be made. Sometimes the appearance of a golden colour on the cut surface immediately after cutting the top portion of the spadix is considered to prove that the cut has been made at the right stage. For a strong and vigorous tree a less matured spadix is often selected for beginning the operation. For weak trees even if the spadix is over-matured it does not matter much. So the exact time at which this operation should be begun is more a matter of experience and judgment.

PREPARATION OF THE SPADIX.

Two methods of preparation are in vogue on the West Coast, and I think it unnecessary to describe

both, as the differences between them are not very striking. The one is known as tapping by "Beating" and the other by "Pounding." These names are given according to the degree of beating or pounding required to weaken the spadix. After selecting the spadix, the cutting of the top with a sharp knife to a length of about 3 or 4 inches is done on an auspicious day of the week preferably Mondays and Fridays. The cut portion is then pounded immediately for a very short time either by means of the handle of the knife or by the pounding stone. Then the spadix is tied very firmly by means of a long fibre taken from the petiole of the coconut tree and kept prepared beforehand so that it may be pliable. The knots are made from the top to the bottom at intervals of two or three inches making in all 6 or 7 knots according to the length of the spadix. In some places this tying is first done and the cut made the second day. Then slightly bending the spadix slowly and carefully, the beating operation is begun with the bone or the horn of the cattle—a description of which is given under appliances—on all the four sides upwards and downwards. Sometimes in order to effect the easy manipulation of the spadix a lengthwise incision is made at the base of the spadix with the tip of the sharp tapping knife. If pounding method is adopted, the cut portion of the spadix is pounded for a short time every day with a small hard granite stone specially shaped for this purpose. With this also occasional beatings are required during the operation. In tapping by beating, slight pounding is done with the handle of the knife alone. Sometimes both the methods are adopted, when it is

found impossible to weaken the spadix by one method alone. It is considered that the regularity and carefullness in beating and pounding will contribute much towards the proper and early flow of the juice and is continued for about 10 to 15 days depending upon the dripping of the juice. During this repeated operation the flowers inside the spadix get crushed and thus further growth and bursting of the spadix is prevented. This is next followed by the bruising at the top cut portion with the rough stipules of the same tree. In places where pounding method is adopted it is not customary to cut the top portion every day until the pounding is continued for about a week. Whereas while tapping by beating a small fresh cut is made every day. After this operation is over the whole spadix is covered by the leaflets of the coconuts keeping them lengthwise and tying firmly. In parts of South Kanara the first dripping juice is allowed to flow towards the base of the spadix by connecting the top cut portion to a slit made at the bottom of the spadix by means of a leaflet. Thus a small quantity of juice will be collected at the base and ferments there. It is said that by doing so the spadix gets weakened quickly. In some cases the bending of the spadix takes place of its own accord, during the frequent handling and beating of the spadix. In some cases as in " Moodankulai " i.e., thick short spadix they are purposely bent either by tying the spadix to the lower leaf or by pushing it down by means of a stick kept above. This is only to facilitate the keeping of the mud pots to collect the juice. When the juice is oozing out in small drops from the cells of the cut portion the spathe surrounding

the inflorescence is carefully cut off from all round to a depth of about 2 inches from above and the flower stalks are thus exposed. These are then tied together firmly by means of a tender leaflet pulled out from the same tree and one portion of the leaflet is allowed to hang as a tongue, so that the juice collected at the surface of the cut portion may drip to the pot easily. In the Laccadive islands during this stage of operation the whole spathe is peeled off and flower stalks alone are tied together firmly. The small piece of leaflet kept hanging to facilitate dripping is locally known as "Tuliola" or "Paniola." This is generally replaced on alternate days as this leaflet will be cut when the daily slicing is being done. Every day both morning and evening fresh thin slices are cut to facilitate better flow of juice and the cut portion is washed clean. If the slicing is not done properly and regularly a sort of frothy appearance will be seen on the top of the spadix hindering the rapid oozing of the juice and the subsequent easy flow to the pot. To avoid this, fresh slicing is made in some places as frequently as three times a day. After the preliminary operation of tying, beating and pounding is over and the juice is seen dripping on the cut surface followed by the hovering of bees and other insects the receptacle, usually a small mud pot, is suspended on the spadix to collect the juice. The exact time at which the flow will begin depends to a certain extent upon the skilfulness of the tapper, weather conditions, and the vigour of the tree as well. The period generally varies from 12 to 20 days. The tender leaves of "Aechil plant" botanically known as *Aporosa Lindlyana*, are rubbed on the

cut end of the spadix every time slicing is done, to clog the interspaces of the flower stalks and thus prevent the inward flow of the juice. In Cochin and Travancore where there is a difficulty of procuring this leaf along the coast, back water silt is made into a paste and used for this purpose. Where fresh leaves are not available every day, these leaves are collected and made into a paste to last for about a fortnight. Other mucilaginous leaves such as those of *Hibiscus Rosa-sinensis* or *Bombax Malabaricum* are sometimes used as a substitute. When the interspaces inside the spathe are too big small flower stalks are cut from other opened spadices and inserted through the cut portion, to prevent the inward flow of the juice. After the collection of the juice is begun no beating or pounding is necessary except slicing, washing and the rubbing of mucilaginous stuff. Sometimes in the hot weather the whole spadix is protected by stipules of coconut trees or dry leaf sheaths of plantains to prevent the exposure of the spadix to the sun. In windy places while suspending the pots they are tied to the spadix by means of a small rope to prevent the pots falling down. When the juice is seen dripping insects of various kinds can be seen hovering round the spadices. To prevent them from getting into the mud pots tappers generally coil round one or two stipules or leaflets and cover the mouth of mud pot in an ingenious way. The juice is collected and removed from the pots once in a day or twice both in the morning and evening.

APPLIANCES.

The appliances required for tapping are few and cheap. The following are the appliances used

on the West Coast :—(1) Ettukathy or Kolakathy, i.e., the tapping knife. The shape of this knife varies from place to place and the price ranges from Rs. 1–4–0 to Rs. 2–8–0 according to locality and shape of the knife. A good knife will last from 5 to 8 years. This knife requires sharpening daily and sometimes even twice a day or even after operating 15 or 20 trees. The strop made use of is the stem of Muringai (*Hyperanthus*), Champaka, *Erythrina Indica*, etc.

Powdered granite stones mixed with water is used as a paste for sharpening. The tappers are very particular in not utilising this knife for any other purpose except tapping. In some places peculiar cases made of light wood or plaited leaves are used to keep the knife safely. (2) Ettukole. Ettu means tapping and kole means stick. This is made either from the horns of buffalo or the shank bone of cattle or deer. When bones are used the hollow portion inside is filled with molten lead to add weight to the same and thus make the beating effective. In Coimbatore the heartwood of tamarind specially shaped as a small club is used for this purpose. This is generally soaked in castor oil for some days before use. (3) The Onday or Surobonday. This is a small long vessel used for carrying water or for emptying juice while tapping. These are made of copper or bamboo pieces or from the fruit of Sorangaykayi or Churangay (bottle gourd) according to the means and convenience of the tapper. (4) Climbing loops and ladders. The only variation in the climbing loop of the tapper in the West Coast is found in the one used by the Mangalore tapper. Here he uses a long string to one end of which the knife is tied. (5) Belts and

hooks. The belts are made of finely twisted coir yarn with two or three hooks made of metals or horn for suspending the appliances round the waist of the tapper while climbing trees. Ornamentations of various kinds can also be seen on these. (6) Brushes. Brushes of various designs are used by the tappers for applying and smearing lime inside the mud pot, if the tapping is done for sweet juice. (7) The receptacle for taking lime varies according to the fancy of the tapper. It may be either a small bamboo piece or a small coconut shell suspended round the waist by a string or hook. (8) The vessel used for emptying the juice is invariably made of bottle gourd fruit, the fleshy portion of which will be scooped out and dried. In rare cases the leaf sheathes of arecanut trees will be folded and stitched for the purpose. (9) Mud pots. Mud pots of various shapes are used in the West Coast for collecting the juice. They are generally smoked before they are hung on the spadix. The mud pots being cool and porous keep the juice much cooler and consequently the fermentation of juice will be slow. The mud pots will last for a year, although there will be much loss in the rainy season. The price various from one to two annas. In the Laccadives bamboo pieces or large coconut shells are used for this purpose.

APPLICATION OF LIME.

When tapping is done for sweet juice freshly slaked lime is smeared inside the mud pot, wherein the juice drips, to prevent the fermentation of the juice. As it is very difficult to regulate the quantity of lime required, it is done in a rough

manner and often adjusted by experience alone. About two tablespoonfuls are generally smeared each time in a pot with a brush for about two minutes. Invariably more lime is added by tappers to prevent fermentation. The addition of excess of lime makes the jaggery malodorous and unpalatable.

QUANTITY OF JUICE AND VARIATION.

Considerable variation is found in the yield of juice. For the first fortnight the juice will be very small in quantity and there will be a gradual increase until the middle portion of the spadix is reached when the yield will be almost steady for a few days and there will be a gradual fall when the bottom of the spadix is reached. There are some trees which do not respond to tapping at all. Such trees are called by tappers rogue trees. It is only when the trees get accustomed to tapping that more juice is obtained. For the first two or three spadices of a tree the yield will be generally less compared with the subsequent spadices. Sometimes if the tapping operation is not begun at the right stage there will be no juice at all and such spadices are left off after a month. Then they produce few nuts if left undisturbed. In the case of a regularly bearing tree as much as three spadices will be yielding juice at a time and from a good tree about 5,000 c.c. of juice can be obtained in a day. The yield of juice is subject to seasonal variations to an appreciable extent.

CONCLUSION.

The sweet intoxicating juice is singularly attractive to all the creatures from the minutest

flies to the gigantic animals. The secret of successful tapping lies only in doing the various operations at the right time and at the right stage. The trees that are tapped and left during one or two seasons are found to be prolific bearers in the subsequent years. But how far the tapping operation will effect the longevity of the tree remains to be seen. There are different directions in which improvements can be effected in the method of tapping about which I shall deal later on. Generally most of the tapped trees present a weak and sickly appearance. This is mostly due to the removal of the leaflet indiscriminately from all the leaves of the tapping tree for the various operations of tapping.

NOTE ON THE MAKING OF ARTIFICIAL FARM-YARD MANURE.

By K. S. VISWANATHA AYYAR, B.A.

Manurial experiments in India have shown that plots treated with cattle or farm-yard manure frequently behave better than those to which mineral manures such as saltpetre, calcium cyanamide, etc., are applied. Investigators have realized that farm-yard manure while slow, has a steady influence on the crop, maintains the "condition" of the soil and shows a sustained residual effect for some years after its application. Bulky organic manures like cakes and fish give generally results better than mineral manures although they fail to come up to the standard of cattle manure under identical conditions.

Although nitrogenous mineral manures have done very well in other countries owing to the different conditions of soil and climate obtaining in such countries, bulky organic manures are more suited to us than concentrated mineral manures because the nitrogen, which is one of the essential if not the most essential of plant foods, is supplied by the former at a slow but steady rate while the latter tend to make nitrogen available at once rushing the plant into prolific growth. Even assuming that the efficiency of the mineral manures will be on a par with the other organic manures, their wholesale utilization by the ryots of Southern India is not at present possible owing to want of facilities for their cheap supply and transport.

It is thus evident that farm-yard manure, if available in sufficient quantities, would figure largely in the manurial programme of the South Indian ryot. Unfortunately a supply of this manure sufficient to meet the demands of South Indian Agriculture is not available. Under these conditions our next hope of supplying this want lies in the use of such bulky organic manures as fish-guano and oil-cakes which however are also not available in sufficiently large quantities or at a reasonable price.

It is, therefore, imperative, that we should turn our attention towards the discovery of new sources of manure. It is essential that these should be available in large quantities and when properly managed behave as efficiently as farm-yard manure or at least approximate to the latter.

H. B. Hutchinson and H. E. Richards of Rothamstead carried out investigations on the utilization

of straw for the production of artificial farm-yard manure. During the course of their experiments they found that raw straw, applied at the time of sowing, caused rather a depressing effect on the crop and that under the best of conditions, the increase in crop over the unmanured plot was very small. If, however, the straw was thoroughly rotted before application they found that the results were very encouraging. They also discovered that rotting of straw readily occurs under aerobic conditions at a temperature of about 35° C. in the presence of about 0·72 parts of soluble nitrogen such as ammonium sulphate for every hundred parts of dry straw. Under these conditions in a well managed experiment, there occurred little or no loss of nitrogen and the final product contained about 2 per cent nitrogen calculated on the dry matter. They have also further shown that if the soluble nitrogen is added in excess,—nitrogen is lost until the percentage reaches the point when fermentation can proceed normally.

It was, therefore, considered desirable to take stock of the available organic waste materials in the country and to see if these could be rendered useful. It was soon realized that we have in India plenty of waste materials such as straws of various kinds, stubbles of fodder grasses, village refuse, prickly-pear, husks of groundnut and paddy and coffee and the tea wastes. Preliminary experiments have, therefore, been started in order to ascertain how far Rothamstead conditions would be suitable for India. As Hutchinson and Richards worked with a straw the material used in this experiment was paddy straw with nitrolim (Calcium cyanamide) as the starter.

1,500 lb. of paddy straw were loosely stacked into a heap 10′ × 6′ × 4′ 2″ in layers of about 3″ thickness. As each layer was spread, water was sprinkled as evenly as possible with a rose can, the total quantity of water used for the whole stack being 276 gallons. Fifty lb. of nitrolim (Calcium cyanamide) were dissolved in 20 gallons of water and sprinkled evenly on the surface of the heap which was then thoroughly moistened by the further sprinkling of 24 gallons of water. The heap was then allowed to ferment under aerobic conditions and watering was done at intervals to maintain the moisture conditions necessary for active fermentation, at the same time taking precautions that the heap was never too wet. In six days the heap began to sink and the average temperature was 59° C. towards the centre and 30° C. at the sides while the colour of the fermenting material changed to brown.

At the end of ten days the temperature at the sides rose to 34° C. whereas in the centre it was 57° C. By this time the material had softened considerably and began to disintegrate. Forty-five days from the time of starting the experiment the straw in the central portion of the heap had rotted a good deal but the disintegration at the sides was not quite satisfactory. The heap was therefore dismantled and thoroughly mixed and restacked. Twenty-four days after this, i.e., 69 days from the inception of the experiment the fermentation was practically complete. The resulting material was soft to the touch, brownish black in colour almost resembling well rotted farm-yard manure, and weighed 2,326 lb. with 66·23 per cent moisture. It

was next submitted to analysis with the following results :—

N. at start.	LB.	*N. at the end.*	LB.
N. in 1,500 lb. of straw ...	6·29	N. in 2,326 lb. of the fermented material.	12·91
N. in 50 lb. of nitrolim ...	8·66	Loss	2·04
Total ...	14·95	Total ...	14·95

From the statement above it is seen that there was a loss 13·65 per cent of the original nitrogen. Judging from these results the field of enquiry seems to be encouraging.

It is possible that by decreasing the amount of nitrogen supplied as the starter and if necessary by slightly modifying the conditions of experiment results approximating those of Rothamstead may be obtained. Experiments in this direction with other materials are in progress.

YIELD OF PADDY AFFECTED BY THICKNESS OF SEED-BED.

By F. R. PARNELL,
Government Economic Botanist.

On a previous occasion, Year Book 1920–21, page 114, figures were given showing that the degree of sturdiness of the seedling, in transplanted paddy, affects the yield of the resulting crop very considerably. The seedlings used in that experiment were selected types from an ordinary seed-bed. A somewhat similar experiment was conducted last season, 1921–22, but in this case the different classes of seedling were raised by sowing seed-beds at different rates.

The variety used was a pure strain of the local Tulukka Samba. Seed-beds were sown, all on the same day and after similar preparatory treatment, at four different rates, as follows :—

(1)	Normal.	1 M.M.	(2½ lb.)	in 1 cent.
(2)	½ „	do.	do.	„ 2 „
(3)	¼ „	do.	do.	„ 4 „
(4)	⅛ „	do.	do.	„ 8 „

The seedlings varied considerably in the different beds, the general sturdiness and tendency to tillering increasing as the seed-rate decreased. Each type was planted on eight strips 40′ × 4′, two repetitions in each of four plots, the seedlings being spaced 6 inches apart each way. The whole planting was finished in one day and the after treatment was the same for all.

There were very marked differences in growth in the early stages, the thinner sown seedlings becoming established more quickly and making better growth. Later growth evened up the differences to a great extent but the quarter and eighth normal types flowered five days earlier than the other two.

All strips were harvested and the grain weighed separately. The grain yields are given below but, for simplicity, the two similar strips in each plot are added together, the figures showing the yield from each plot only for the four types.

Plot.	Normal.	Half normal.	One-fourth normal.	One-eighth normal.
2 E	124	131	136	145
3 E	140	150	143	148
4 E	117	132	139	135
5 E	126	137	147	148
Total	507	550	564	576
Relative ..	*100*	*108·6*	*111·4*	*113·8*

These results confirm those of the previous year in showing that a substantial increase in crop results from decreasing the seed-rate. It is probable that the increased crop resulting from a reduction of the seed-rate to 1 m.m. in 2 cents would, in very many cases, more than cover the extra cost of preparing a greater area of seed-beds. A point to be considered is that the seed-bed area would not have to be doubled as the seedlings from 1 m.m. of seed would go further, in planting, if sown more thinly in the seed-bed.

LIFE-HISTORY OF *PUNDALUOYA SIMPLICIA* —THE CHOLAM LEAF-HOPPER.

By Y. RAMACHANDRA RAO,
Acting Government Entomologist.

**Pundaluoya simplicia* is a small bug of the Fam. Fulgoridæ, which infests cholam and maize and sometimes cumbu. Under favourable circumstances it is capable of proving a serious pest, the top shoots being in such cases crowded with nymphs. The interior of the top whorls become filled with their gummy excreta and, in extreme cases, rotting is induced. The bug is small, about 3 m.m. long (from head to end of abdomen), and dusky brown in colour. The wings are clear and transparent, with the veins brown with a few dusky marks at the apex and are folded roof-like over the abdomen when at rest.

Egg.—The eggs are laid inside the tissues of the mid-rib being thrust into slits prepared by the sabre-like ovipositor of the female. They are

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* *Pundaluoya simplicia*, Dist. has since been determined to be identical with *Dicranotropis maidis*, Ashm.—an insect of world-wide distribution—by Professor D. L. Crawford of Honolulu.

small, pale white objects, curved in form; the inner end is much thickened while the outer extremity is narrow and is visible through the slit made by the ovipositor. They are laid without special preference from the upper or the lower surface of the leaves and to a superficial view look like rows of little white specks on the midrib. The eggs hatch in about 8 to 10 days as may be seen from the following table :—

Laid.	Hatched.	Length of period.
1. 26—27—X—'15.	3—4—XI—'15.	8 days.
2. 29—30—X—'15.	6—7—XI—'15.	8 days.
3. 30—31—X—'15.	7—8—XI—'15.	8 days.
4. 2—3—X—'15.	12—13—XI—'15.	10 days.

Nymph : I instar.—The newly hatched nymph is about 0·7 m.m. in length very pale brown, with the exception of the abdomen which is slightly darker and the eyes which are a brilliant red. The body is thickset on the whole and the legs are disproportionately large. The eyes are oval and are composed of a few large facets ; the antenna is composed of 4 joints of which the basal one is short and sessile, the second short, the third thickened, and the fourth oval and bears a many-jointed hair-like "arista". The front of the face is reclinate and is marked by a deep facial groove bounded by sharp frontal carinæ; while on either side there is a lateral carina bounding a lateral sulcus. Dorsally the thorax is divided into two halves by a median suture, while the three divisions of the thorax are clearly demarcated by distinct oblique sutures. The wing-rudiments are hardly indicated. The

legs are large, somewhat flattened. The two anterior tarsi are one-jointed, while the tarsi of the hind legs are two-jointed.

II instar is 1·25 to 1·50 m.m. in length. The third joint of the antenna is somewhat larger, while the IV joint is smaller. In the thorax, the lateral edges of the II and III segments show a slight enlargement, indicating the rudiments of the wing-buds. Faint oblique ridges are noticeable on the three thoracic segments—one on each side of the dorso-median line. Legs as in I instar ; but in the III pair of legs, spines have appeared on the I tarsal joint and a distinct spur on the tibia. A dark grey bloom all over the body with the exception of a mid-dorsal stripe, which is broad on the thorax and narrower on the abdomen, and the intersegmental bands on the abdomen and thorax —all of which are pale grey. Tips of tarsi black.

III instar : about 2 m.m. long. III antennal joint more swollen ; the IV very small. The wing-buds have grown backwards and are more distinct. The I pair overlaps a part of the II, while the II pair reaches the second abdominal segment. The ridges on the thoracic segments are more distinct. The tibial spur on the III pair of legs quite large. Colouration more or less as in II instar.

IV instar : about 2·5 m.m. long ; antenna with the basal joint small, the II larger, the III swollen and more elongate, and the IV quite small. The metathoracic wing-buds cover the first three segments of the abdomen, while they are themselves overlapped in great part by the first pair of wing rudiments. The dorsal ridges are more prominent. The tarsi of the anterior pairs of legs have developed two joints, but are not spiny, while the

posterior tarsi are three-jointed, and their spurs are larger and the spines longer. Colouration as in previous instar.

V instar : about 3 m.m. long ; III antennal joint more elongate ; the I pair of wing-buds has developed enormously and covers the II pair almost entirely except for the extreme tip which just reaches the V abdominal segment. The ridges on the thorax are more prominent. The hind legs with the tibial spur almost as long as the I tarsal joint. The spines, of which there are 5 on the tibiæ, 7 on the 1st tarsal joint and 2 on the 2nd, are quite large. Apices of the tarsi black.

Colouration somewhat darker. The grey band between the pro-and meso-thoraces is gracefully curved and forms a sort of cross with the dorso-median stripe. Black patches are noticeable on the sides of the VI, VII, IX and X abdominal segments. The length of the nymphal period varied from 16 to 20 days as studied in the following cases :—

Moults.	A_1	B_1	C_2	C_4	D	D_1	G_2	H
Hatched	7-8-I-'15	9-10-I-'15	11-12-I-'15	11-12-I-'15	12-13-I-'15	12-13-I-'15	18-19-I-'15	19-20-I-'15
I Moult	11-12-I-'15	12-13-I-'15	15-16-I-'15	15-16-I-'15	16-17-I-'15	16-17-I-'15	22-23-I-'15	23-24-I-'15
II Moult	15-16-I-'15	16-17-I-'15	18-19-I-'15	17-18-I-'15	18-19-I-'15	18-19-I-'15	24-25-I-'15	25-26-I-'15
III Moult	17-18-I-'15	18-19-I-'15	22-23-I-'15	20-21-I-'15	21-22-I-'15	21-22-I-'15	27-28-I-'15	27-28-I-'15
IV Moult	21-22-I-'15	21-22-I-'15	26-27-I-'15	23-24-I-'15	25-26-I-'15	25-26-I-'15	30-31-I-'15	30-31-I-'15
V Moult	26-27-I-'15	26-27-I-'15	31-I-1-II-'15	28-29-I-'15	29-30-I-'15	30-31-I-'15	3-4-II-'15	4-5-II-'15
	an adult. ♀	adult.	adult. ♂	adult. ♀	adult. ♀	adult. ♀	♂ adult half-winged form.	♂ adult half-winged form.

It is interesting to note that some individuals of this species appear to assume a hemipterous or halfwinged form, wherein the wings cover only half the abdomen and are functionless.

With the idea of finding out whether the micropterous form is identical with the macropterous one, attempts were made to find whether the micropterous form could be bred out from the full-winged form and vice versa. Large numbers of specimens of males and females of both forms were collected and kept in cages separately. Eggs laid by them on cholam plants (which had been examined thoroughly and found free from eggs) were kept separate and the young ones hatching from eggs laid by the two forms were separately let on young cholam plants grown in cages. The young bugs could not, however, be reared to maturity except in the case of one cage, where the offspring of fullwinged females had been let on cholam plants grown in pots under a large cage on the 6th November 1921 and more than 5 half-winged male and female bugs were noticed on the plants when examined on the 4th December 1921, in addition to several nymphs. None of the full-winged forms were noticeable. Though this experiment is not conclusive and will have to be confirmed by further rearings, it is fairly clear that the micropterous and the macropterous forms are only variations of the same species.

Distribution.—This insect has been noted throughout the Presidency and is probably distributed throughout India and Ceylon.

Remedial measures.—In small areas the pest can be readily checked by spraying with kerosene emulsion, but in large areas, treatment will not be practicable under present Indian conditions.

SOME OF THE DIPLODIAS FOUND IN SOUTHERN INDIA.

By S. SUNDARARAMAN, M.A.,
Government Mycologist,
AND
K. M. THOMAS, B.A.,
Assistant in Mycology.

No.	Host Plant.	Locality.	Date of collection.
1	Bursera belpechiana	Bangalore	28 Nov. 1921.
2	Theobroma cacao	Kottayam, Travancore.	Mar. 1922.
3	Hevea braziliensis	Travancore, Cochin ...	26 Sep. 1912.
4	Areca palm	Coimbatore	July 1922.
5	Ficus Benjamina	Do.	11 Nov. 1918.
6	Camellia theæ	South India	19 Nov. 1914.
7	Moringa pterygosperma ...	Coimbatore	29 Sep. 1916.
8	Citrus sp.	Gōdāvari	June 1922.
9	Erythrina lithosperma ..	Sidapur, Coorg ...	Do.
10	Saccharum officinarum ...	Coimbatore	April 1922.
11	Opuntia Dillenii	Trichinopoly	30 Jan. 1916.
12	Anona squamosa	Coimbatore	Aug. 1922.
13	Cocos nucifera (leaf base) ...	Malabar	31 Oct. 1922.
14	Do. (fruit) ...	Travancore	1921.

1. DIPLODIA ON BURSERA BELPECHIANA.

Pycnidia gregarious, blackish brown, immersed in a stroma, erumpent, globose-depressed, smooth or sparsely hairy, ostiolate, 1–3 in a stroma, paraphysate, about 500 μ in diameter. *Paraphyses*: copious, hyaline, filiform, 50-100 μ long.

Spores first hyaline and nonseptate, turning brown and uniseptate, oblong to ovoid, rounded at ends, 17-21 μ × 10-13 μ. Average of 32 measurements 19·3 × 11·6 μ.

Habitat: On dead branches of Bursera belpechiana, Bangalore.

2. DIPLODIA ON THEOBROMA CACAO.

Stroma scattered, containing 1-3 pycnidia in each.

Pycnidia Sub-erumpent, confluent, rarely single, immersed in a stroma, dull black, conoid or elongate, ostiolate, hairy at mouth, with paraphyses, 300-400 μ × 250-300 μ.

Paraphyses hyaline, filiform, copious, 50-80 μ long.

Spores first hyaline, nonseptate, ovoid to oblong: then brown and uniseptate, unconstricted at septum, 20-25 μ × 12-14 μ. Average of 32 measurements : 21·6 × 12·3 μ.

Habitat : On the bark of dead cacao stem, Kottayam, Travancore.

3. DIPLODIA ON HEVEA BRAZILIENSIS.

Pycnidia gregarious, occurring 1-3 in a stroma, dull black, basal half immersed in a stroma, erumpent, conico-depressed, ostiolate, smooth, broader than long, without paraphyses 250-300 μ × 300-400 μ.

Spores first hyaline and nonseptate, then brown and septate, not constricted at septum 20-26 μ × 12-15 μ. Average of 30 measurements : 23·5 × 13·5 μ.

Habitat : On bark of dead branches of Hevea braziliensis, Travancore.

4. DIPLODIA ON ARECA PALM.

Pycnidia scattered, occurring single, minute, punctiform, superficial, black, papillate, globose-depressed, slightly woolly, with paraphyses, 180-240 × 200-260 μ

Paraphyses copious, hyaline, filiform to clavate 30-60 μ long.

Spores Oblong, rounded at ends, first hyaline, nonseptate, then brown and uniseptate, 20-26 μ ×

12-15 μ. Average of 30 measurements : 24·5 μ × 13·3 μ.

Habitat : On dead leaf sheaths of Areca palm in Coimbatore.

5. DIPLODIA ON FICUS BENJAMINA.

Stroma very dark, imbedded in the bark.

Pycnidia cespitose, 1-6 in a stroma, erumpent, globose, ostiolate, short dark hairy growth on surface, black, 300-400 μ in diameter, paraphysate. *Paraphyses* hyaline, filiform, 40-80 μ long.

Spores first hyaline and nonseptate, growing dull brown and uniseptate with age, not constricted at septum. 22-26 μ × 12-15 μ. Average of 30 measurements : 24·1 × 13·3 μ.

Habitat : On roots of Ficus Benjamina, Coimbatore.

6. DIPLODIA ON TEA STUMP.

Stroma scattered, 1-3 pycnidia in each.

Pycnidia immersed in a stroma, black, inner layers light brown, erumpent, nonostiolate, conico-depressed, slightly arched, but generally distorted by crowding, wall of pycnidium indistinguishable from stroma, paraphyses absent, 400•500 × 600-700 μ. Pycnidial cavity alone measuring 200-400 × 300-500 μ. Conidiophores light brown.

Spores hyaline and nonseptate, then turning light brown and uniseptate (rarely) 2 septate, one spore was found to have 3 septa, measuring 23-30 × 12-14 μ. Average of 30 measurements : 25· 8 × 12· 5 μ.

Habitat : On roots of Camellia thea, South India.

.7. DIPLODIA ON MORINGA PTERYGOSPERMA.

Pycnidia scattered or gregarious, 1-5 in a stroma, sub-epidermal, slightly erumpent, ostiole not found, dull black, first immersed in the stroma, conoid when single, distorted when clustered, no paraphyses, measuring 300·350 μ × 250·350 μ.

Spores hyaline and nonseptate at first, then turning bright brown and uniseptate, ovoid to oblong, rounded at ends, not constricted at septum, 15-21 μ × 10-12 μ. Average of 40 measurements : 16·45 μ × 10·35 μ (in sections, hypha shows pear shaped swellings near the septa).

Habitat : On bark of dead branches of Moringa pterygosperma, Coimbatore.

8. DIPLODIA ON CITRUS SP.

Pycnidia scattered, black, occurring single, immersed in stroma, erumpent, wall indistinguishable from stromatic tissue, ostiolate, conical, measuring 200-350 × 200-300 μ including the stroma.

Spores hyaline and nonseptate, as also dark brown and uniseptate, oblong ovoid, ellipsoid, etc., not constricted at septum. (A number of uniseptate spores are characteristically vacuolate, one big vacuole in each cell) 22-28 μ × 115-14·5 μ. Average of 40 measurements : 24·4 × 13·4 μ. (Spores germinate in 3-5 hours in glucose agar plates.)

Habitat : On dying branches of Citrus sp. Gōdāvari, South India.

9. DIPLODIA ON ERYTHRINA LITHOSPERMA.

Stroma scattered, dull black, contains 1-2 pycnidia.

Pycnidia erumpent, black, ostiolate, sub-epidermal, globose or conical with a hyaline mycelial

lining. Paraphyses present, measure 300-400 μ in diameter.

Paraphyses copious, hyaline, filiform 50-65 μ long.

Spores hyaline and nonseptate, turning brown and uniseptate, not constricted at septum, ovoid to oblong, rounded at ends 22-28 $\mu \times$ 12-14 μ.

Habitat : On bark of dead branches of Erythrina lithosperma, Sidapur, Coorg.

10. DIPLODIA ON SUGAR-CANE.

Stroma inconspicuous, scattered, but congregating near the nodes, black.

Pycnidia solitary, rarely confluent, papillate, submerged below the rind then erumpent, smooth, conico-depressed or arched (reniform), paraphysate 250-350 $\times$ 350-500 μ.

Paraphyses copious, hyaline, filiform to slightly clavate, 35-70 μ long.

Spores first hyaline and nonseptate, ovoid to oblong, rounded at ends, measuring 21-26 $\mu \times$ 11-13 μ. Average : 23·5 $\times$ 11·8 μ.

Habitat : On internodes of reedcanes, Coimbatore.

11. DIPLODIA ON OPUNTIA DILLENII.

Pycnidia gregarious, minute, punctiform, black, sub-epidermal, papillate, globose, paraphysate, 200-250 μ in diameter.

Spores hyaline and nonseptate, also brown and uniseptate, not constricted at septum, 16-20 $\mu \times$ 10-14 μ. Average of 30 measurements : 18·7 $\times$ 11·8 μ.

Habitat : On dead stem of Opuntia Dillenii, Trichinopoly.

12. DIPLODIA ON ANONA SQAMOSA.

Pycnidia sparse, minute, immersed, in the bark, occurring single without evident stroma, black-globose or globose-depressed, papillate, paraphysate, 200-210 μ in diameter.

Paraphyses hyaline, clavate, 30-50 μ long.

Spores ovoid or oblong, rounded at ends, first hyaline and nonseptate, then brown and uniseptate, not constricted at septum, 18-24 μ × 12-13 μ.

Average of 40 measurements : 20·8 × 12·8 μ.

Habitat : On dead branches of Anona squamosa, Coimbatore.

13. DIPLODIA ON COCONUT (LEAF BASE).

Pycnidia gregarious, superficial, protruding from the epidermis, globose, or globose-depressed, papillate, black, sparsely hairy, paraphysate, 200-340 μ × 300-400 μ.

Paraphyses copious, hyaline (branched) filiform, forming a felt lining the pycnidium, 40-65 μ.

Spores hyaline and nonseptate or brown and septate, ovoid to ellipsoid, 20-25 μ × 11·5-13 μ.

Average of 30 measurements : 22·8 × 12·2 μ.

Habitat : On the leaf base of dead coconut leaves, Pattambi, Malabar.

14. DIPLODIA ON COCONUT (FRUIT).

Pycnidia scattered, subdermal, occurring single without evident stroma, suberumpent, conico-depressed, flattened to oblong shape or slightly arched, smooth, without ostiole, paraphyses rare and inconspicuous, cavity lined by hyaline growth.

Spores ovoid or oblong, hyaline and nonseptate or brown and uniseptate, 20-25 μ × 10-13 μ. Average of 30 measurements : 22·0 × 12·4 μ.

Habitat : On prematurely fallen nuts of Cocos nucifera, Travancore.

A SHORT NOTE ON MANGOSTEEN.

By M. AROKIASAWMY,

Officiating Curator.

Garcinia mangostana, L.—The mangosteen is indigenous to the Malay Islands. The fruit is about the size and shape of an orange, brilliantly coloured outside with rich purple and is considered one of the most delicious fruits of the tropics. Some writers describe it as "perhaps the most luscious fruit in the world partaking of the flavour of the strawberry and grape". Yet, this fine fruit, remains to this day extremely limited in its distribution and is known only to a few who have lived or travelled in the Southern parts of this Presidency.

2. The mangosteen is a small tree rarely over 30′ high, compact in growth and regular in outline with dense large dark green foliage. The tree is grown in few places in India. There are a few specimens in Courtallum, in Tinnevelly district, and there are at present 22 trees, growing in the Government Fruit Garden at Burliar, 11 miles below Coonoor at the junction of the old and new Ghat roads near the Toll-gate at an elevation of 2,500′ above mean sea-level, having an average rainfall of 60″ per year. These trees were planted about 1874 ; they are growing and fruiting well

3. The acclimatization of the mangosteen in many other parts of India, is a possibility and the principal difficulties of its culture have probably

risen from an ignorance of the soil conditions demanded by the plant. It is said that the mangosteen can be grown only within four or five degrees of the equator. Such a statement is not warranted by facts. It is true that this tree is strictly tropical in its requirements and its demands in regard to soil conditions are definite. There is no reason, however, to assume that it will not be possible to grow mangosteens successfully throughout the tropics wherever these conditions can be met.

4. The essential condition for its cultivation is a hot moist climate and rich soil. Propagation is usually by seed, but may also be effected by grafting, gootee, or layering. There are grounds for the hope, therefore, that commercial production of this delectable fruit will not remain limited to a remote region like Burliar.

5. *Cultivation from seeds.*—Well ripened, large fruits should be selected. A large fruit usually contains 2 or 3 fertile seeds. It is best to sow the seed with the edible pulp adhering and as fresh as possible. As the seeds are very delicate, the vitality will be greatly weakened or entirely lost, if kept too long.

The seeds ordinarily germinate in a fortnight to a month, from sowing. They should be sown about a foot apart in Nursery beds that are 4′ wide and any convenient length. Throughout the time they remain in the Nursery, the bed should be daily watered as well as occasionally manured with Farm-yard manure or leaf-mould.

Well-grown seedlings would be at least a foot in height at the close of the year and bear about 6 to 8 leaves. At the commencement of the rains, the seedlings should be very carefully removed

from the Nursery beds and planted out in pits previously prepared. These pits are best dug at a distance of 30′ from one another and should be located in open, well-drained, loamy land. They should be 3′ square and 3′ deep and be filled in with surface soil, leaf-mould and cattle manure, well mixed. The plants should be shaded with bamboo and dried plantain leaves or grass tatties, placed horizontally over each plot and supported upon bamboo uprights 4′ high. This shade should be given soon after the seedlings are planted and be maintained for at least one year. The tatties may be removed when there is rain, as well as during nights. Watering must be regularly given during dry months of the year for at least 2 years after they are planted.

6. Dr. Fairchild of United States of America, who has studied its requirements more exhaustively, considers that the unduly limited distribution of the tree is due to the difficulty which young plants have in establishing themselves, and he believes that a vast extension of mangosteen culture will take place when the root system of this tree is thoroughly understood. This may come about through the use of stocks which are less particular in their soil requirements. With this view, grafting by inarching has been done on several mangosteens on *Garcinia xanthochymes*, a vigorous and hardy species of what is commonly called the "sour mangosteen." This is a widely distributed species met with in Eastern Bengal, the Eastern Himalaya from Sikkin to the Khasia mountains, Burma, Southern India, Penang and the Andaman Islands. The result of this grafting will be known a few years hence, since

several species of *garcinias* are known, there should be excellent possibilities of obtaining a stock plant which will produce robust mangosteen trees on soils where they will not grow successfully on their own roots.

7. In Ceylon and Singapore the best orchards are on soil having a high clay content, combined with plenty of coarse material and a small amount of silt and where the water table stands about 6 feet below the surface. "The impression is current," says Dr. Fairchild, "that the mangosteen requires a wet, but well-drained soil and a very humid atmosphere."

8. The observation made by Dr. Fairchild during his studies of mangosteen culture are of such importance that it is worthwhile, to reproduce one of them here. He writes of his visit to Mr. H. N. Wright at Mirigama, Ceylon.

"His orchard consisted, at the time of my visit in 1902, of 23 trees and was then probably the largest in the colony. It was from eight to ten years old, having been planted with two-year-old trees which were sent him as a present from the Malay Peninsula. The selection of a site for his orchard was a very happy one; a moist spot in his coconut plantation, a part of which had at one time been used as a rice field. The ground was so moist that open drains were cut through it to carry off the superfluous water and these are still kept in order. The soil of the squares on which the trees are growing is so moist and soft that, were it not for a layer of coconut husks, one's feet would sink in up to the ankle as he walks across them. The roots, under these circumstances, are bathed continually in fresh, not stagnant, moisture. Mr. Wright attributes his success in growing mangosteens to the fact that he has planted them on soil that never dries out, but has, at a few feet from the surface, a continual supply of fresh moisture. The water in his well, nearby, is six feet from the surface of the ground. H. L. Daniel, who has been for 15 years trying to grow this fruit, and who, during that time, has planted over a hundred young trees, assures me that this is

one of the secrets of the culture of this difficult fruit and gives Mr. Wright credit for first finding it out."

"Another important detail relates to the matter of transplanting the young seedlings. Mr. Daniel plants the seeds in a small pot or coconut husk, and keeps them well watered and slightly shaded with a coarse matting of coconut leaves. He transplants them from this small pot to a larger one when the roots have filled it; and in removing he cuts off the tap-root if the latter is exposed. For two years these young plants are kept in pots and grow to a height of two to two and a half feet. It is useless to transplant them before they are at least two feet high, for the check given them, if too young, by the transplanting is so great that they refuse to grow."

"When transplanted, the plants are set in a hole three feet cube in size. Stiff soil is best but is not absolutely necessary, as they will grow in a light soil if the subsoil is a good paddy mud. From the first the young trees should be shaded with a matting of coconut leaves, which is suspended two feet or so above the top of the plant. This is to prevent wilting and the subsequent death of the two red, partly developed leaves, which first appear from the seed, and which must be kept alive if the plant is to make a rapid growth. If these precautions of potting, shading, and selection of soil are followed, trees should come into bearing seven years from seed, producing a small crop of a hundred fruits or so. The subsequent treatment of the mangosteen orchard seems to be very simple,—no pruning of any kind is commonly practised, although it might be advisable to prune; and little cultivating is done. A mulch of coconut husks about the base of the tree to keep the surface soil continually moist, and the application of a small amount of earth from the poultry-yard, sprinkled about underneath the trees each year, are the only attentions given them. Whether or not artificial fertilizers could be employed with profitable effect is a question that has not been answered."

9. A healthy seedling plant, when 10 years old is capable of yielding from 200 to 300 mangosteens valued at from Rs. 8 to Rs. 12 per 100. An acre planted at 30 feet apart from one another would hold 50 plants. And if, at the end of the tenth year, they yield on an average 200 fruits

each, valued at the rate of Rs. 10 per 100, the plantation of one acre would yield an approximate income of Rs. 1,000.

10. The mangosteen at Burliar begins to flower about May, ripens fruit in September and continues till end of November. Each tree bears about 800 or more fruits. The mangosteen crop at Burliar was a record one during 1921 and a sum of Rs. 1,309 was collected by the sale of fruits. Large number of mangosteen seedlings have also been raised during 1921. These are growing well at present but are rather small.

FEEDING EXPERIMENTS, BANGALORE.

By R. W. LITTLEWOOD, N.D.A.,
Deputy Director of Agriculture, Live-stock.

EXPERIMENT I.

The following feeding experiment was conducted at the Bangalore Military Diary with the intention to see whether it benefited a dairy man to include 3 lb. of rice bran in his cow's ration. All the cows in the experiment were halfbred, their food was weighed daily, and they were fed in troughs. In some instances, a certain amount of stealing amongst the cows went on, but this could not be avoided owing to the construction of the troughs. There were two groups of six cows. Every effort was made to procure cows whose total weight, their number of days in milk and their total daily milk yield corresponded as nearly as possible.

The milk was weighed and tested for fat each morning and evening. Each animal was weighed

before the experiment and at the end of each week during the experiment and their weights recorded.

The rations fed to the two groups were as follows :—

	Group I.	Group II.
	LB.	LB.
Cotton seed meal	3	3
Wheat bran	3	3
Rice bran	3	...
Gram husk	2	2
Brewers grain (wet)	16	16
Salt	oz. 1	oz. 1
Silage	20	20
Green grass	10	10
Hay	5	5

GROUP I.

Number.	Age.	Daily milk yield before experiment commenced.	Weight.	Number of days in milk.	Number of calves.	Date of serving.
	Y. M. D.	LB.				
834	3 1 12	23	800	59	1st calf ...	Not served.
711	3 5 12	24	750	44	1st ,, ...	15th January 1920.
426	5 3 12	17	820	9	3rd ,, ..	27th January 1920.
429	5 2 12	22	720	58	2nd ,, .	28th December 1920.
709	3 5 12	20	670	65	1st ,, ..	13th January 1920.
828	2 8 12	17	600	69	1st ,, ...	Not served.
	Total ...	123	4,360	304		

GROUP II.

497	4 5 12	20	810	95	1st calf ...	16th January 1920.
518	4 0 0	20	670	39	3rd ,, ...	17th January 1920.
513	4 1 12	24	880	79	1st ,, ...	Not served.
714	3 4 12	19	530	21	1st ,, ...	Do.
812	2 10 12	21	510	26	1st ,, ...	2nd February 1920.
549	8 0 0	19	570	41	4th ,, ...	31st January 1920.
	Total ...	123	3,970	301		

WEIGHT OF COWS.

GROUP I.

Number.	Weight at commencement of experiment.	Weight after the experiment.	Increase or decrease in weight.
	LB.	LB.	LB.
834	800	860	+ 60
711	750	750	...
426	820	840	+ 20
429	720	740	+ 20
709	670	730	+ 60
828	600	660	+ 60
Total ...	4,360	4,580	+ 220

GROUP II.

497	810	860	+ 50
518	670	720	+ 50
513	880	890	+ 10
714	530	600	+ 70
812	510	580	+ 70
549	570	610	+ 40
Total ...	3,970	4,260	+ 290

WEEKLY YIELD OF MILK.

GROUP I.

Number.	1st week.	2nd week.	3rd week.	4th week.	5th week.	Total.
	LB.	LB.	LB.	LB.	LB.	LB.
834	159	152	148	153	147	...
711	181	180	178	168	154	...
426	140	155	157	161	152	...
429	152	146	149	147	140	...
709	148	139	144	147	135	...
828	137	136	123	130	129	...
	917	908	899	906	857	4,487
Fats, Average per cent.	M. E. 4·28 5·41	M. E. 4·48 5·35	M. E. 4·15 5·04	M. E. 4·30 5·08	M. E. 4·20 5·18	M=Morning. E=Evening.

WEEKLY YIELD OF MILK—*cont.*

GROUP II.

Number.	1st week.	2nd week.	3rd week.	4th week.	5th week.	Total.
	LB.	LB.	LB.	LB.	LB.	LB.
497	143	134	136	130	129	...
518	138	143	133	132	127	...
513	160	156	159	156	146	...
714	139	138	140	139	130	...
812	144	141	145	140	136	...
549	118	114	117	117	109	...
	842	826	830	814	777	4,089
Fat per cent.	M. E. 4·32 5·25	M. E. 4·31 5·22	M. E. 4·44 5·12	M. E. 4·37 5·18	M. E. 4·21 5·21	

From the above it will be seen that the total increase of milk of group I over group II is 398 lb. in 5 weeks. If this milk is taken at the usual Bangalore price, *viz.*, annas 3 per lb. there is a sum of Rs. 74–10–0.

The amount of rice bran consumed by the 6 cows in group I for the 5 weeks amounted to 630 lb. The price paid for this bran was Rs. 4-0-0 per 130 lb. therefore the 630 lb. cost Rs. 20–9–0.

From the above it can be concluded that by feeding this extra 3 lb. rice bran, a profit of Rs. 54–1–0 was made and this works out approximately at Rs. 9 per cow for 5 weeks, that is Rs. 1–12–0 per week or 4 annas per day.

Group II gained 290 lb. and group I, 220 lb. in body weight in the 5 weeks, but I think this can be discarded as some cows put more flesh on than others.

As paddy is grown extensively in this Presidency it behoves the ryot to use this bran, which can be purchased at all local markets and mills for feeding his breeding stock as it is a good food where milk is required.

EXPERIMENT II.

The following experiment was tried in order to see if by substituting 20 lb. of green fodder (Rhodes grass) in a cow's ration by 12 lb. silage, made of maize and cholam any increase or decrease in milk yields was noticeable.

It may be worth while mentioning here that silage is only green fodder crops (such as maize and cholam, etc.,) cut whilst they are green and stored in pits which must be dry, the fodder is either chaffed or put in long ; it is pressed down by weights or by bullocks trampling it in order to squeeze out all the air and so make one large compressed mass. This silage can be used for feeding the cattle when grazing is scanty and when there are no green fodder crops growing, it comes fresh out of the pit and dairy cattle relish it very much when once they have accustomed themselves to it. Silage is an excellent fodder for India.

This experiment was conducted at Bangalore with crossbred cows and lasted two months. The cows were milked three times a day at 2 a.m., 8 a.m. and 2 p.m. As before animals (5 in each group) were selected and efforts made to procure cows about the same weight, the same number of days in milk and which yielded about the same amount of milk.

The rations fed to the animals consisted of—

	Group I.	Group II.
	LB.	LB.
Mixture	7	7
Groundnut cake	3	3
Brewers' grain, wet	12	12
Salt	2 oz.	2 oz.
Silage	12	20
Hay	Unlimited.	Unlimited.

The mixture was made up of—

Bran.
Cotton seed meal.
Rice meal.

Hay is put in racks in the paddocks and the cows are allowed to eat as much as they want. The milk was weighed and tested each day and records kept. The cows were each weighed before the commencement of the scheme and at the end of each week and their weights noted.

GROUP I.

Number of cow.	Date of birth.	Daily milk yield.	Weight.	Number of days in milk at commencement.	Number of calves.	Date of service.
		LB.	LB.			
893	14-3-18	23	780	9	2	25-9-22
818	18-4-17	23	700	101	3	8-7-22
792	9-11-16	29	760	16	4	5-10-22
961	25-11-18	30	830	91	1	3-8-22
495	25-7-15	32	970	61	4	2-8-22
	...	137	4,040	278	...	...

GROUP II.

967	21-1-19	26	720	9	2	16-8-22
207	14-2-19	23	760	101	1	8-7-22
888	27-2-18	29	800	19	2	17-9-22
426	20-11-14	27	990	90	5	19-9-22
821	1-5-17	29	780	58	3	15-7-22
	...	134	4,050	277	...	...

WEIGHT OF COWS.

GROUP I.

Number.	1st week.	2nd week.	3rd week.	4th week.	5th week.	6th week.	7th week.	8th week.	9th week.
	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.
893	746	746	782	794	752	760	804	780	760
818	716	706	717	734	676	680	734	728	746
792	716	708	719	750	720	680	736	728	720
961	840	842	848	854	824	825	844	840	840
495	1,012	1,004	1,020	1,030	990	1,000	1,046	988	1,020
	4,030	4,006	4,086	4,162	3,962	3,945	4,164	4,064	4,086

GROUP II.

967	740	742	770	756	746	744	780	752	740
207	802	816	800	830	810	820	850	832	836
888	828	846	856	860	904	836	876	860	880
426	972	1,006	920	1,034	980	972	1,004	960	980
821	780	800	796	830	746	750	824	892	746
	4,122	4,210	4,142	4,310	4,186	4,122	4,334	4,296	4,182

WEEKLY YIELDS OF MILK IN LB. PER COW.

No. of cow.	1st week.	2nd week.	3rd week.	4th week.	5th week.	6th week.	7th week.	8th week.	9th week.

GROUP I.

	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LP.	LB.
893	163	175	180	174	170	170	167	166	170
818	158	157	149	146	149	147	145	136	143
792	205	202	194	199	191	182	175	168	171
961	208	210	212	208	200	194	203	201	200
495	215	206	204	197	192	189	187	166	178
	949	950	939	924	902	882	877	837	862
	M. E.	M. E.	M. E.	M. E.	M. E.	M. E.	M. E.	M. E.	M. E.
Fat per cent...	3·5 5·2	3·4 5·3	3·4 4 8	3·4 5·0	3·3 5·2	3·4 5 0	3 6 5	3·2 5	3·5 5·2

GROUP II.

967	175	175	173	175	172	163	159	155	161
207	161	168	166	163	156	147	146	146	149
888	195	197	194	186	192	187	183	173	180
426	195	188	190	189	181	175	176	164 ×	174
821	191	183	179	181	177	148 ×	142	145	142
	917	911	902	894	878	820	806	783	806
	M. E	M. E	M. E.	M. E.	M. E.	M. E.	M. E	M. E.	M. E.
Fat per cent...	3 4·8	3·2 5·5	3 3 5·1	3·4 5·1	3·4 5·4	3·5 5·4	3·6 5·1	3·4 5·4	3·6 5·6

The experiment has not given us very much information. Cow No. 821 fell sick during the sixth week of the experiment and never quite regained its normal yield. Cow No. 426 was sick during the last week of the experiment also.

The average daily Milk-yields of the two groups up to the end of the fifth week does not show much difference, as Group I commenced with a total daily yield of 137 lb. and Group II, 134 lb. at the end of the fifth week. Group I yielded 126 lb. and Group II, 122 lb., whereas at the end of the experiment Group I yielded 117 lb. and Group II, 108 lb.

The weights of the animals at the commencement of the experiment and at the end of it, do not show very much difference.

The only conclusion one can come to from the above experiment is that 6 lb. silage is equal to about 10 lb. of green grass (Rhodes) for feeding to Dairy Cattle.

EXPERIMENT III.

The Milkmen of Madras have a great prejudice against groundnut cake as a food for a milch cow ; so the following experiment was conducted at Bangalore to determine the feeding value of three different kinds of cake, viz., groundnut cake, linseed cake, and gingelly cake.

2. Three groups of 5 cows each were selected and were arranged in groups as near as possible to relate to daily yield, days in milk and body weight.

3. The rations were mixed for each group and labelled separately. Each group had 42 bags of rations, each containing 55 lb. of concentrates, the brewers' grain being issued fresh daily. The same men milked the cattle throughout.

4. During the 6th week one of the cattle No. 209-A in Group I fell sick so that it would be as well to take results up to the end of the fifth week :—

All the cows were milked 3 times a day, their milk was weighed daily and the milk tested for fat.

The rations fed to the cows consisted of—

—	Group I.	Group II.	Group III.
	LB.	LB.	LB.
Linseed cake	2	...	...
Groundnut cake...	...	2	...
Gingelly cake	...	...	2
Rice Meal	2	2	2
Cotton seed hulls	2	2	2
Wheat Bran	3	3	3
Cotton seed hulls	1	1	1
Gram	1	1	1
Brewers' grain	12	12	12
Hay	10	10	10
Silage	25	25	25

PARTICULARS OF THE COWS.

No. of cow.	Date of birth.	Daily milk yield before experiment commenced	Weight.	No. of days in milk.	Date of service.	No. of calves it had till it came into experiment.
			GROUP I.			
		LB.	LB.			
457	6- 4-15	27	1,016	103	29- 6-21	4
898	19- 3-18	24	800	120	6- 7-21	2
967	21- 9-19	22	700	27	30- 9-21	1
862	24- 9-17	26	876	117	20- 5-21	2
209-A	17- 3-19	23	556	69	...	1
	Total ...	122	3,948	436	...	...
			GROUP II.			
478	22- 6-15	26	916	103	14- 7 21	3
301	12- 3-12	24	876	78	16--9-21	6
865	7-10-17	22	636	122	19- 6-21	2
904	23- 3-18	31	840	42	5- 9-21	2
972	24- 1-19	21	684	94	12- 8-21	1
	Total ...	124	3,952	439	...	...

PARTICULARS OF THE COWS—*cont.*

No. of cow.	Date of birth.	Daily milk yield before experiment commenced.	Weight.	No. of days in milk.	Date of service.	No. of calves it had till it came into experiment.
			GROUP III.			
		LB.	LB.			
495	25- 7-15	25	988	110	14 8-21	3
888	27- 2-18	26	812	51	24- 9-21	1
870	25-10-17	21	758	133	2-10-21	2
500	28- 9-15	30	936	118	1- 7-21	3
77-A	15-10-17	21	780	27	...	1
	Total ..	123	4,274	439	...	...

WEIGHT OF COWS SHOWING INCREASE OR DECREASE DURING EXPERIMENT.

No. of cow.	Weight at commencement of experiment.	Weight at end of experiment.	Increase or decrease.	Remarks.
		GROUP I.		
	LB.	LB.	LB.	
457	1,016	1,040	+24	
898	800	840	+40	
967	700	730	+30	
862	876	906	+30	
209-A	556	520	−36	Fell sick.
			+88	
		GROUP II.		
478	916	880	−36	
301	876	905	+30	
865	636	641	+12	
904	840	882	+42	
972	684	728	+42	
			+90	
		GROUP III.		
495	988	1,006	+18	
888	812	828	+16	
870	758	786	+28	
500	936	968	+32	
77-A	780	806	+26	
			+120	

WEEKLY YIELD OF MILK.

No. of cow.	1st week.	2nd week.	3rd week.	4th week.	5th week.	6th week.	Total
GROUP I.							
	LB.	LB.	LB.	LB.	LB.	LB.	
457	188	179	174	173	166	160	1,040
898	173	178	170	165	162	159	1,007
967	155	155	158	157	152	147	924
862	184	179	163	164	149	154	993
209-A	166	152	145	129	125	71	788
Total ...	866	843	810	788	754	691	4,752
	M. E.	M. E.	M. E.	M. E.	M. E.	M. E.	
Fat per cent ...	3·6 5·3	4·0 5·5	3·6 5·4	3 8 5·2	3·8 5·5	3·7 5·6	
GROUP II.							
478	180	171	160	160	146	153	970
301	168	161	162	154	149	149	943
865	151	148	147	142	128	139	855
904	221	213	208	198	203	201	1,244
972	144	145	186	144	149	147	915
Total ...	864	838	863	798	775	789	4,927
	M. E.	M. E.	M. E.	M. E.	M. E.	M. E.	
Fat per cent ...	3·5 5·5	3·6 5 4	3·6 5·4	3·7 5·2	3·8 5·4	3·8 5·4	
GROUP III.							
495	169	163	162	160	160	161	975
888	173	167	169	167	160	160	996
870	155	149	151	155	150	154	914
500	203	203	203	193	191	188	1,191
77-A	152	153	143	162	160	157	927
Total ...	852	835	828	837	821	820	4,993
	M. E.	M. E.	M. E.	M. E.	M. E.	M. E.	
Fat per cent ...	3·8 5·7	3·9 5·5	3·5 5·3	3·6 5·2	3·6 5·4	3·7 5·6	

From the results obtained it will be seen that Group No. III did better than either Groups I and II in the yield of milk and also the weight of the animals, but when the price of this cake is compared with the price of groundnut cake fed to Group II cows it will be seen that it is much more

economical as gingelly cake costs Rs. 8-5-4 per 100 lb. at Bangalore and Rs. 6-10-0 at Madras and groundnut cake costs Rs. 4-7-6 per 100 lb. at Bangalore and Madras.

After this experiment I should advise milkmen to feed groundnut cake instead of gingelly cake as it is a great saving.

The superstition of the Madras milkmen that groundnut cake is not as good as gingelly cake for feeding milk cows is not well founded as the amount of milk yielded by feeding gingelly cake does not cover the extra cost of it.

				RS.	A.	P.
Cost of feeding the cake—Gingelly			...	29	2	8
		Groundnut	...	15	10	3
		Linseed ...	...	23	5	11
Value of extra Milk 88 lb.		Group I ...	...	16	8	0
Do.	90	II ...	...	16	14	0
Do.	120	III ...	...	22	8	0

ORGANIC MANURES—AVAILABILITY OF PLANT FOOD

By K. ADINARAYANA RAO, L.Ag.

It is well known that for their nutrition all plants depend upon the food material available in the soil and in the manure applied. It is therefore of extreme importance to determine how much of the food material in any manure becomes available when added to a soil. Food stuffs are valued for the digestibility or availability of their food material, and the same is true of manures.

Organic nitrogenous manures when applied to a soil undergo a series of changes owing to the

activity of soil bacteria resulting first in the breaking down of complex albuminoid substances. Next comes a change leading to the production of ammonia and its final oxidation into nitrous and nitric acids. The nitrogen in an organic manure is said to be "available" to the degree in which it is readily converted into nitrates. Nitrates are the end product of these changes and are readily assimilated by all plants. Measure of nitrification is, therefore, considered a safe method of determining the availability of nitrogen in manures. Many soil Biologists in Europe, America and India have often emphasised this view, and some of them consider that the fertility of a soil could thereby be safely predicted.

In order to ascertain the availability of plant food in Indian manures, when applied to important soil-types, experiments described below were carried out. Figures available up to the present relate to green-leaf manures and oil-cakes, and are described in this paper.

The soil selected for the purpose was garden land taken from the Central Farm, Coimbatore. In colour it is reddish and forms an important soil-type.

TABLE I.

Analysis of Green-leaf manures.

No.	Common name.		Botanical name.	Percentage of nitrogen in
	Tamil.	Telugu.		Fresh leaf with 90 per cent water.
1	Erukam ..	Jillede	Calotropis gigantea.	0·3669
2	Avarai ...	Tangedu ...	Cassia auri culata ..	0·3135
3	Pungam ..	Kanuga ..	Pongamia glabra ...	0·3669

TABLE II.

Analysis of oil-cakes.

No.	Common name.	Botanical name.	Percentage of nitrogen in
1	Illuppai cake	Bassia Longifolia ...	2·41
2	Pungam cake	Pongamia glabra ...	4·50
3	Black Castor cake	Ricinus Communis ...	6·60
4	White Castor cake ..	Do. do. ...	9·10
5	Neem cake	Azadirachta Indica ..	5·88

N.B.—Cakes that are used as cattle food were omitted from the experiment.

Green-leaf manures were added to give 30 milligrams of nitrogen per 100 grams soil. Optimum moisture was determined and sufficient water added. The soil was air-dried, sampled and sieved before use. Two hundred gram lots of dry soil were taken, requisite quantities of water and leaves added, the whole mass mixed well, put in glass jars and incubated at 30° C. for a period of eight weeks. Loss in moisture was made up every fourth day. Amounts of ammonia, nitrates and nitrites were determined once at the end of four weeks, and a second time at the end of the experiment.

Soil equivalent of 100 grams dry soil was taken. This was made up to 300 c.c. with water and shaken for 30 minutes. The soil emulsion was then filtered until 30 c.c. of clear filtrate had been collected, and the remaining portion of the emulsion was set apart for estimating ammonia. Nitrites in the filtrate were estimated by Griess-Illosway method, and nitrates by the Phenol-sulphonic acid method, the colours obtained matching the standardized glasses in the Tintometer. The remaining portion of soil extract was

acidified with dilute hydrochloric acid and left for twenty-four hours. From this, aliquot parts of the supernatant liquid were distilled off with calcined magnesia and ammonia was estimated by the titration method. N/20 acid and N/20 alkali were used for the purpose. Table III shows results. Both ammoniacal and nitric nitrogen figures are given.

TABLE III.

Green-leaf manures.

No.	Common name.	Milligrams of nitrogen in the leaf added.	Milligrams of active nitrogen formed after						Percentage of availability at the end of 8 weeks.
			4 weeks.			8 weeks.			
			NH_3	NO_2	NO_3	NH_3	NO_2	NO_3	$(NH_3 + NO_3)$
1	Avari ...	30	6·50	Nil.	Nil.	6·75	Nil.	1·00	25·83
2	Erukam.	30	7·02	„	5·14	7·60	„	8·49	53·33
3	Pungam.	30	6·02	Trace.	3·60	7·30	Trace.	4·20	38·33

In the case of oil-cakes, the determinations were made once in two weeks. Four hundred gram lots of dry soil were used. Eight weeks was the period of incubation. Cake was added at 30 milligrams nitrogen per 100 grams soil. Deficiencies of moisture were made up once in four days. Estimations of ammonia, nitrates and nitrites were made by the methods described above. Table IV shows results of nitric nitrogen. Only nitric nitrogen figures are given, since the cakes are generally applied to arable land where the conditions are favourable for nitrate formation.

TABLE IV.

Oil-cakes.

No.	Common name.	Milligrams of nitrogen in the cake added.	Milligrams of nitrate nitrogen formed after.				Percentage of availability (No. 3) at the end of 8 weeks.
			2 weeks.	4 weeks.	6 weeks.	8 weeks.	
1	Black castor cake.	30	7	13	15	17	57
2	White „ „	30	7	12	18	24	80
3	Illupai cake ...	30	...	...	...	..	...
4	Pungam cake ...	30	7·5	11	13·5	15	50
5	Neem cake ...	30	6·5	11	13	17	57

The above tables (III and IV) represent figures given after deducting the controls.

SUMMARY AND CONCLUSIONS.

Green-leaf manures.—Cassia auriculata which is largely used by the Indian cultivator as a green-leaf manure does not seem to be of immediate use to the first crop. The nitrogen becomes so slowly available that this leaf does not compare favourably with other green-leaf manures. This aspect of the manure problem is being experimented upon at the present time. It seems likely that the tannic acid in the leaf is really responsible for the initial inhibitory action. In a period of eight weeks only 3·33 per cent of nitrogen was available as nitrate : but if we add ammonia also, nearly 25·83 per cent of the nitrogen becomes available.

Pongamia-glabra is the next higher, but does not fulfil the hopes entertained of it by the cultivators, only 14 per cent of its nitrogen being

available as nitrates in the course of eight weeks. With ammonia, the percentage of available nitrogen increases to 38·33 per cent.

Calotropis-gigantia seems to be the best since 28 per cent of its Nitrogen is available as nitrates during the same period. This is in entire accord with the popular practice. When ammoniacal nitrogen is added on, the availability per cent rises to 53·33 per cent.

Of all the cakes tested, white castor was found to be best, as 80 per cent of its nitrogen becomes available for the nutrition of a growing crop in the course of eight weeks. In the same period 57 per cent of nitrogen in black castor cake is nitrified, thus showing that the removal of the husk (i.e., decorticating) enhanced the availability of castor, and the ryot may, with advantage, go in for the decorticated cake wherever possible. 57 per cent of the nitrogen in neem and 50 per cent in pungam become available in the same period. In some localities Pungam is in great demand, but the value of Neem is not sufficiently realized.

Illuppai cake is peculiar. It resists all bacterial action in the soil at least during a period of eight weeks. This inhibitary character is perhaps due to the presence of a large percentage of a poisonous glucoside "Saponin" (29 per cent to 31 per cent), and it is a problem whether it would not be worth while attempting to remove the "Saponin" with a view to make it nitrifiable as the cake contains 2·41 per cent nitrogen, i.e., five times as much as is contained in the Farm yard manure. Further work will elucidate this point. In its raw state it has absolutely no manurial value.

Experiments are in progress with other organic manures, and will form the subject of a contribution when the results are available.

CASUARINA ROOT NODULES AND NITROGEN FIXATION. (PRELIMINARY CONTRIBUTION.)

By K. ADINARAYANA RAO, L.Ag.

The accumulated experience of centuries has taught the agriculturist that certain leguminous crops enrich the soil somehow. This belief found its practical application in olden times, and persisted at a period in the nineteenth century when it could not be explained by the then scientific methods. The earliest recorded observations on the root-nodules of the leguminosæ did not connect the presence of these root swellings with the reputed soil-enriching qualities of the legumes.

To the scientists of the seventeenth century they were only root galls, and to those of the early nineteenth century they appeared as pathological processes caused by fungi, or merely as modifications of the normal roots. During the latter half of the nineteenth century scientists devoted much time and energy to the study of the origin of the root nodules, and to ascertain their significance, Microscopic examination revealed the presence of, micro-organisms in the cells of the nodules, and these organisms were assumed to be the agents of nodule formation, but still the old idea that they were pathological in origin and therefore harmful, held the field until the epoch-making researches of Hellriegel and Wilfarth were published. They

clearly showed to the world that the leguminous root nodules were caused by bacterial infection from the soil, and that this infection is beneficial to the plants. They regarded the tubercles as laboratories where the formation of suitable nitrogenous compounds took place.

This discovery led other scientists to study the bacteria in the nodules of leguminous plants. The results of their work have confirmed the views of Hellriegel and Wilfarth, establishing the symbiotic relationship between bacteria and the legumes in the fixation of air nitrogen. It thus became clear that the practice of growing plants for enriching the soil was not without a real foundation.

In temperate regions scientists found the nodules on the roots of

(1) The Alder.
(2) The Eleaguus.
(3) The Podocarpus (the White Pine).
(4) The Cycas (Cycas cercinalis).

Investigations were made in the tropics also, and the rapid plant growth helped scientists in their efforts. Of the new plants that were found to contain tubercles on their roots, casuarina is one, and the credit of having noted their presence goes to Dr. C. A. Barber, who supposed them to be diseased portions. The nodules seem, on the contrary, to be beneficial, and the bacteria inhabiting them seem capable of fixing appreciable quantities of nitrogen from the air, and of supplying the tree with suitable nitrogenous compounds.

Narasimhan (1918) made a preliminary study of the root nodules of casuarina, and seems to be the only author in India who has done any work on the subject.

In the following pages is indicated the work done in regard to the bacteria inhabiting the nodules.

For this purpose a few nodules were cut, and put in flasks containing 100 c. cs. mannite solution (Ashby's) and incubated at 30° C. for three weeks. Control flasks were provided. At the end of the incubation period, nitrogen determinations were made, and there was a large excess of nitrogen in the experimental flasks over the controls.

This fact led to further study on the physiological role of the nodules and their inhabitants with reference to the growth of the tree. The preliminary experiment showed a fixation of 498 milligrams of nitrogen per gram of mannite after deducting the nitrogen of the control flask. This laboratory result, coupled with the observation that the tree grows well on poor and sandy soils, leads one to think that casuarina root nodules may be beneficial in character, and that they may correspond in functional activities to those of legumes.

TREATMENT OF NODULES.

The nodules were sterilized by the following method recommended by Joshi (1920).

The nodules were carefully washed in distilled water and dropped in a sterilized test tube containing a few cc. of warm mercuric chloride solution (temperature 40° C.). This test tube was then re-plugged with cotton wool and placed in a filtering flask fitted with a rubber cork. The flask was then connected to the filtering pump and the air exhausted till the solution began to boil. In this way all the air bubbles present on the surface of

the nodules were withdrawn, and on admission of air by disconnecting the pump, the nodules sank to the bottom of the test tube and the disinfectant solution was able to act on all portions of the nodule.

Sterilization was allowed to proceed for two to three minutes, after which the tube containing the nodules was taken out. The mercuric chloride solution was poured out and the nodules were washed five times with sterile water. The nodules were teased and crushed inside the tube by means of a sterile scalpel.

Two loopfuls of the cloudy emulsion that resulted were transferred to a melted tube of mannite agar, three loopfuls from this to a second, and again three from the second to a third tube of mannite agar. The contents of the tubes were separately poured into three petri dishes and incubated at 30° C. Observations were made every twenty-four hours. The colonies began to appear on the third day, and on the fifth day they were ready for inoculation.

The colonies were all of the same kind and looked pure. They were gummy, white and glistening. Slides were prepared from the colonies and examined under the microscope. Rodshaped Bacteria were noticeable.

One cc. of the cloudy suspension from the tube in which the nodules had been crushed was put into each of the three Erlenmeyer flasks in duplicate. One flask from each series was then autoclaved to serve as controls, and all six were incubated at 30° C. Each of the flasks contained 100 cc. of nitrogen-free solution with two grams of mannite. After three weeks' incubation,

nitrogen determinations were made, and the following table shows results after deducting the nitrogen of the controls :—

No.	Milligrams nitrogen fixed per gram mannite.	
1	5·93	5·84
2	5·75	
3	5·87	5·89
4	5·91	

Just before the culture flasks were digested for nitrogen determinations, two loopfuls of the scum was taken with a sterile platinum loop and inoculated into fresh flasks. This sub-culturing was carried to as many as five generations with a view to purify the culture.

STAINING.

The organisms are stained by the usual aniline stains. When Kiskalt's Amyl gram stain was used better results were obtained. Harrison and Barlow have recommended the specific use of this stain for the root nodule organism of the leguminosæ.

The writer has found that by this method of staining, the organism stains deep violet. The background is cleared up, the Bacteria appear prominent, and their structure can be clearly seen. Young agar cultures stain very well.

Saffranin followed by Lugol's solution may be used to stain smear preparations from nodules. This method demonstrates the presence of starch grains.

The organism seems to be a strong aerobe as it fixes larger quantities of nitrogen in thinner layers of the liquid medium in equal-sized flasks than in deeper layers.

ITS NITROGEN FIXING POWER.

The following table gives amounts of nitrogen fixed when mannite solution flasks were inoculated with the cloudy suspension got by teasing out the nodules. The period of incubation varied, and the temperature was 30° C. Nitrogen determinations were made, and the control figures were deducted. The net increase in nitrogen is given in the table below :—

No.	Period of incubation (in days).	Milligrams N. fixed per 100 cc. mannite solution with 2 grams mannite.	Per gram mannite.
1	49	17·74	8·87
2	42	13·18	6·59
3	35	12 16	6·08
4	35	12·23	61·15
5	21	10·48	5·24
6	20	9·94	4·97
7	14	7·12	3·56

It is evident from the above table that nitrogen fixation is quite intensive and that the capacity of this organism seems to be greater than the Leguminosæ organism.

The foregoing preliminary studies prove that in addition to its many uses, Casuarina enriches the soil, and the soil conditions are improved in a similar way as when legumes are grown. The fact that Casuarina thrives on sandy soil notoriously deficient in plant food, is proof enough to show that the root nodules have a distinct part to play in the growth of the tree. It is abundantly clear from the above tables that these nodules act as

laboratories and as means of supplying nitrogenous compounds readily assimilable by the growing tree.

In certain tracts in India Casuarina is used as a soil enricher in soils which are considered unfit for the growth of other trees, and after a certain period, the soils are reclaimed for growing valuable fruit trees, thus showing that Casuarina improves the soils and makes them fit for the growth of plants that otherwise could not be cultivated. This interesting practical observation confirms the laboratory results noted above.

SUMMARY AND CONCLUSIONS.

1. The occurrence of nodules on the roots of plants wide spread, and casuarina affords a striking example of this phenomenon.

2. Casuarina Root Nodules are extremely beneficial and have a definite part to play in the growth of the tree.

3. The fixation of nitrogen is quite vigorous, and compares favourably with others.

4. Mannitol solution and mannite agar are admirably suited as liquid and solid media.

5. The organism is a strong ærobe, and this laboratory observation seems to co-relate with the natural home of the Casuarina, viz., the thoroughly ærated sandy soil.

6. The Bacteria are rod-shaped and in advanced stages curved forms are noticeable.

7. The organism can be easily isolated by the usual laboratory methods.

8. The biological functioning of this organism is similar to that of the Leguminosæ organism, and therefore it is worth while growing the Casuarina on a much larger scale than is the case at present.

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